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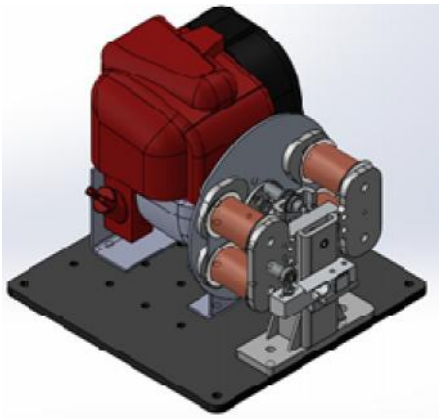
DYNAMOMETRY & ENGINE TESTING

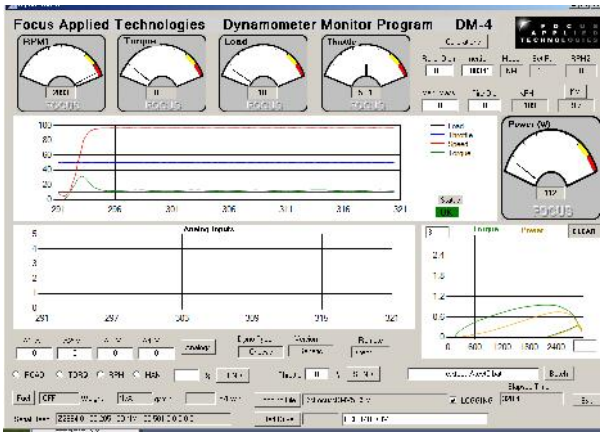
Using Desk-Top Dynamometer

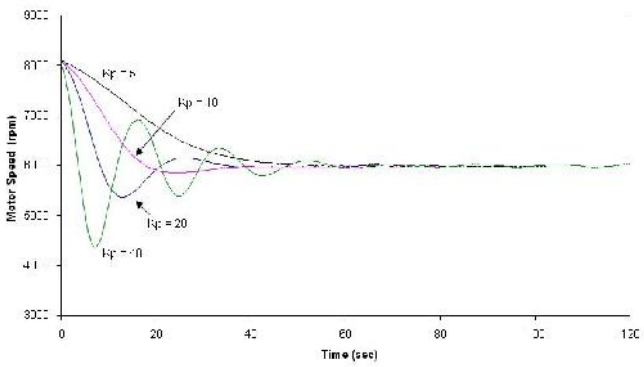


In this course the flexible “DeskTop Dynamometer” is used to explore many aspects of Engine Testing. The DeskTop Dynamometer comes with a Honda GX35 Gasoline Engine, and dynamometer controller, together with software for displaying and logging data from the engine. Various experiments are described, along with theoretical considerations, and then demonstrated live, including analysis of the resulting data.

Covered Topics Include:

* Dynamometry Basics
    - Speed Measurement
    - Torque Measurement
    - Load Control
    - Throttle Control
* Speed Control Mode
* Torque Control Mode
* Engine Characterization
    - Wide Open Throttle Torque Curve
    - Part Throttle Torque Curve
* Dynamometry Characterization
    - Dyno Torque Curves
* Engine Frictional Torque
* Thermal Torque Degradation
* Inertial Dynamics
* Control System Dynamics
    - Overshoot
    - Slew Rate
    - Setting Time
* Proportional Control
* Differential Control
* Remote Operation
* Automated Testing
* Additional Engine
* Instrumentation
    - Temperature
    - AFR
    - Fuel Consumption





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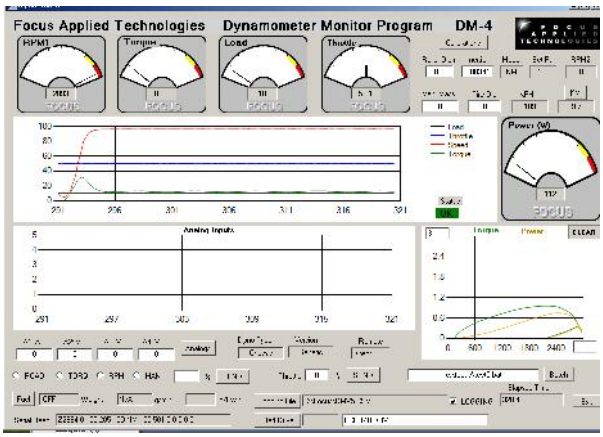
AC MOTOR PERFORMANCE & EFFICIENCY TESTING

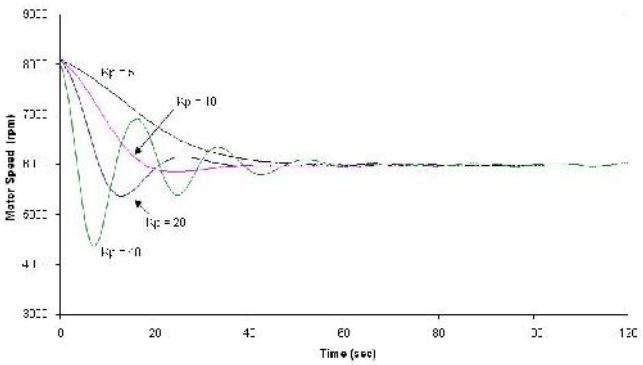
This seminar is an in-depth review of AC Motors used in industrial processes, focusing on the larger multi-kilowatt machines. Engine performance theory and measurements are covered in great detail, along with live demonstrations of various measurement techniques. Load - Source matching and the cost of mismatching is reviewed, with calculations of the cost of improperly sized motors. Various efficiency enhancements are covered including power correction capacitors, voltage clipping and variable frequency drives, again with live demonstrations. Additional information relating to new vs. rewound motors, motor starting and coupling is also covered. Finally industrial energy assessments and testing services are described.

The emphasis is on demonstrating actual, practical techniques using real equipment. Additionally time is provided for discussion of questions from the industrial audience.

Covered Topics Include:

* AC Motor Basics
  Motor Performance: Torque, Current and Efficiency
* Load - Source Matching
* Motor Measurements
  On-Line Measurements
  Dynamometer Measurements
* Load Mismatch and Efficiency
* Starting Considerations
* Efficiency Improvements:
  Power Factor Capacitors
  Voltage Clippers
  Variable Frequency Drives (Inverters)
* Other Considerations:
  Standard vs. Premium Efficiency Motors
  New vs. Rewound Motors
  Bearings, Belting and etc.
* Industrial Assessment and Motor Testing Services





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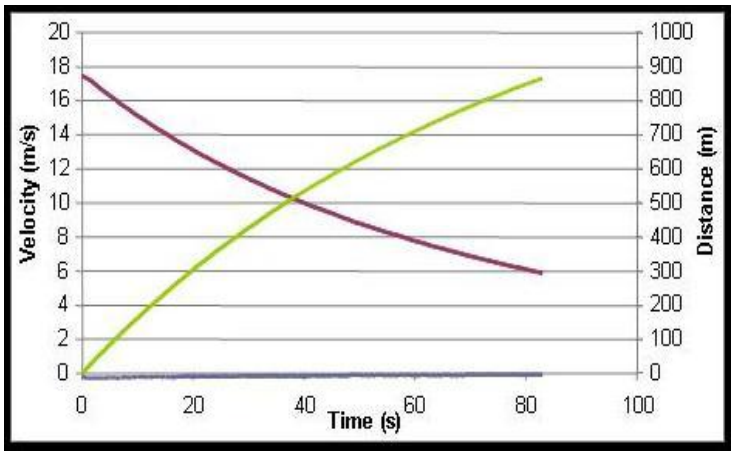
“HYPERMILEAGE” VEHICLE OPTIMIZATION



Model of Vehicle Power Consumption - Pulse & Glide

Vehicle Parameters		**Assumed Constants**			
M	100 kg	Cd	0.15	DT	1
Area	0.35 m²	Crr	0.001		
		g	9.81 m/ss		
		Air Dens	1.18 kg/mmm		
Operational Parameters					
V	40 km/h	11.1 m/s			
A	0 m/ss	Power	53.4 W		
Vehicle Performance		**Engine Performance**			
Faero	3.8 N	Torque	7.3 Nm		
Froll	1.0 N	BSFC	250 g/kWh	3.10	Kw
Facell	0 N	RPM min	2100 rpm		
		RPM max	6000 rpm		
Min Speed	22 km/h	6.1 m/s			
Max speed	62.9 km/h	17.5 m/s			
Wheel Dia	0.7 m	Gear Ratio	12.59		20
		Whl Trq	91.9 Nm		18
		Force	257. N		
		Acell	2.57 m/ss		
Graphic Estimates		**FC Predictions**			
Ton	2 s	TONtotal	46.1 sec		
Toff	80 s	FC	9.9 gm	0.01	
Dist	867 m	Mileage	1451.7 km/l		
Total Dist	20000 m				

This seminar gives an overview of vehicle dynamics as related to power consumption based on our history of “hypermileage” competition successes. Engine performance data from a wide variety of internal combustion engines, as well as electric motors is presented, and matched to the vehicle model to determine the ultimate energy consumption in km/liter of fuel, or km/kWh of electrical energy.

Vehicle design parameters are adjusted to simulate improvements in mass, rolling resistance, size and aerodynamic drag, with resulting implications on fuel efficiency. Various driving techniques, including both cruise and “pulse and glide” are explained and analyzed in depth. Finally engine modifications are analyzed for efficiency improvements.

Covered Topics Include:

- Vehicle Dynamics
- Drag Coefficient and Frontal Area
- Rolling Resistance
- Parasitic Losses
- Engine Efficiency: BSFC Map
- Engine Tuning for Efficiency
- Engine Design for Maximized Efficiency
- Overall Vehicle Fuel consumption estimation

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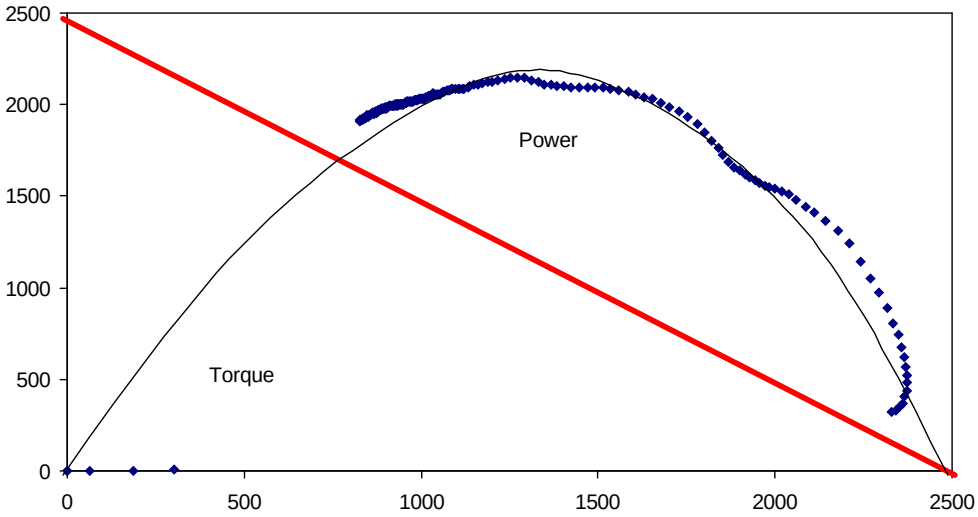
VEHICLE DYNAMIC



This seminar will covers vehicle performance measurements including engine torque/power, as well as gear ratio measurements, friction, and breaking effectiveness.

Covered Topics Include:

- Basic Vehicle Dynamic
- Vehicle Efficiency
- Resistance
  - Vehicle's mass (inertia or resistance to acceleration)
  - Aerodynamic resistance
  - Rolling Resistance
  - Grade Resistance
- Tractive effort
  - The relation
  - Tire friction
- Vehicle acceleration
- Braking
- Stopping distance

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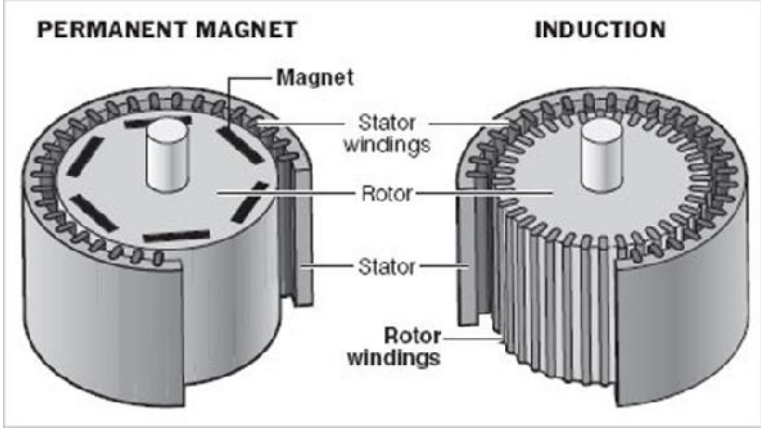
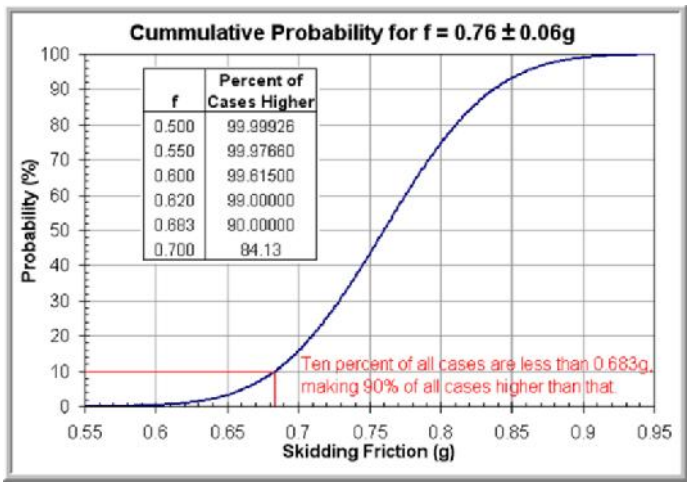
INDUSTRIAL ELECTRIC MOTOR EFFICIENCY MEASUREMENT & CONTROL



This seminar gives an overview of electric vehicles as to highlight the current " state of the art" pf EV's and their associated problems. Engine performance data from a wide variety of internal combustion engines, as well as electric motors is presented, and matched to the vehicle model to determine the ultimate energy consumption in km/liter of fuel, or km/kWh of electrical energy.

Covered Topics Include:

- AC Induction Motors Characteristics
- Load Characteristics
- Load Source Matching
- Efficiency Measurements: Dynamometer and In The Field
- Efficiency Improvements:
  - * Proper Sizing
  - * High Efficiency Motors
  - * Voltage Reduction
  - * VFD (Inverters)
  - * Power Factor Corrections
- Economics and ROI calculations



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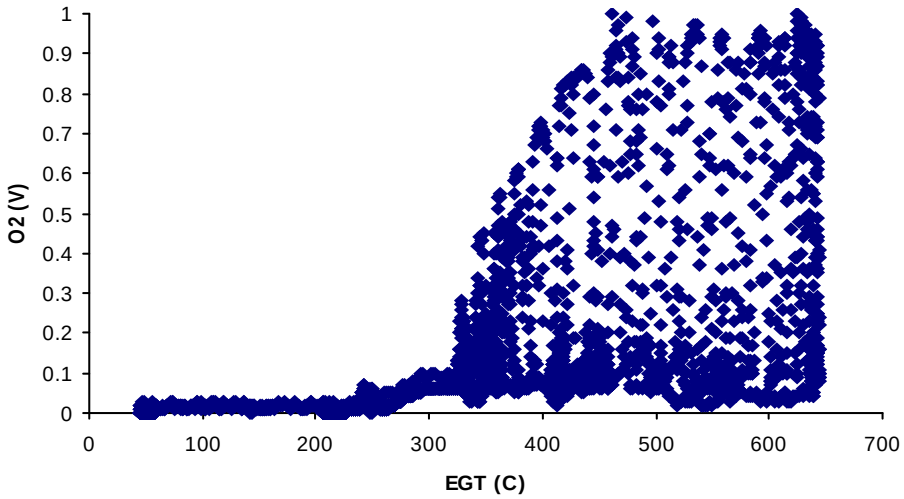
VEHICLE DATA LOGGING



This seminar serves as a comprehensive overview of cataloging measurements from vehicles. It is broken into 2 major parts:

Data Logging and Signals
This covers the various sensors and their signals as well as other signals readily available and of interest on most vehicles. Function, use of and limitations of the data logger are presented as well.

Vehicle Dynamics
This covers vehicle performance measurements including engine torque/power, as well as gear ratio measurements, friction, and breaking effectiveness.

Covered Topics Include:
- Signals and Sensors
- Voltage/time based Measurement
- Data Logger Memory Limits
- Vehicle Dynamics
- Vehicle Data Measurements

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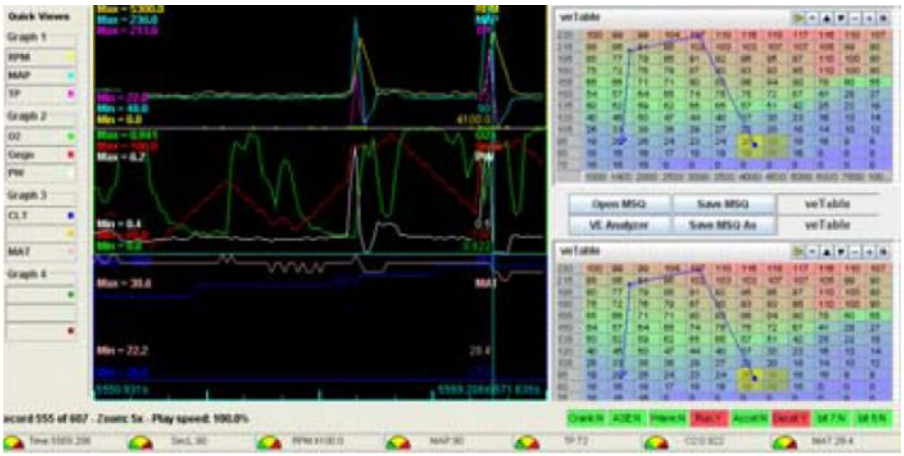
ELECTRONIC FUEL TUNING SYSTEM



This seminar serves as a comprehensive overview of modern Electronic Fuel Injection systems. During this course we explain the basic operation the various sensors (TPS, MAP, MAT, Temperature, CPS, O2…) and their signals. The various actuators (Ignition, fuel injector, Idle Speed Control Valve, O2 Heater...) are covered in depth as well. The basic control strategies (N-alpha, Speed-Density and Mass Air Flow) are explained in detail, enumerating calculation of the fuel injection duration to achieve the required air/fuel ratio. Emissions are explained based on combustion chemistry along with how to control emissions with ignition timing, injection and catalyst effects taken into consideration. Finally we will conclude with a number of compensations made based on altitude, temperature acceleration/deceleration and for cold starting.

Covered Topics Include:

- Sensors and their signals
- Actuators and their control
- Optimizing Injector Spray
- EFI Control: N-Alpha, Speed-Density, MAF
- EFI system mapping
- Emissions Controls
- Acceleration / Deceleration
- Temperature Effects
- Ignition timing, torque and emissions
- Cold Starting
- Altitude Effects

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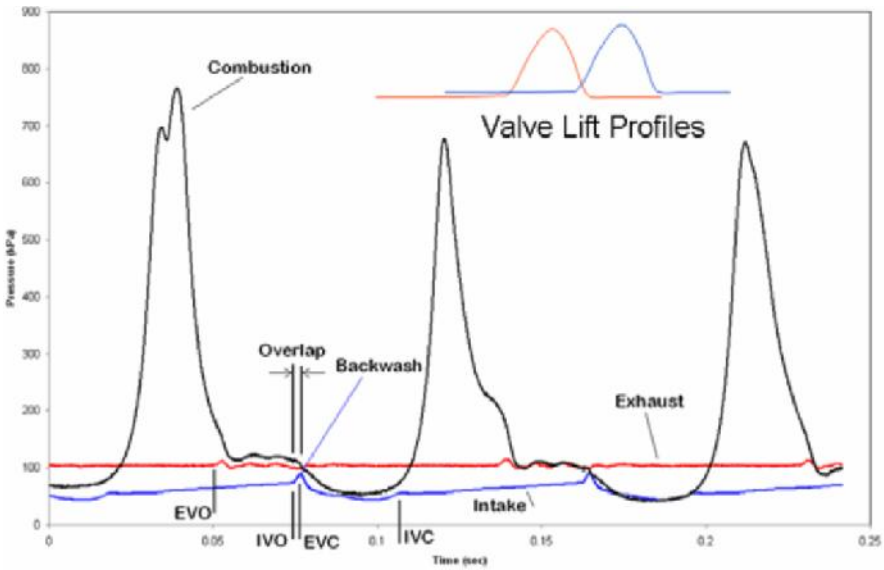
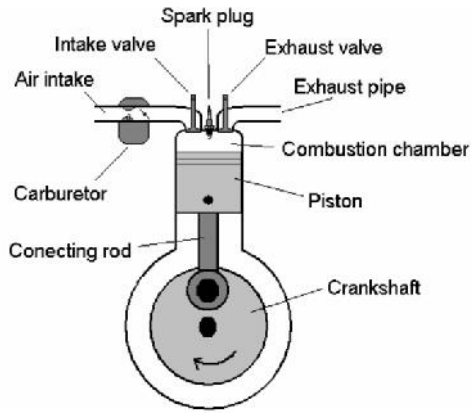
INTERNAL COMBUSTION ENGINES



This seminar serves as a comprehensive overview of modern two- and four-stroke spark ignited and diesel engines. During this course we explain all of the major engine components and their function. Combustion chemistry, heat transfer and thermodynamics are covered in depth to allow calculation of engine power, emissions and fuel consumption. Special emphasis is given to engine efficiency, friction, combustion efficiency and pumping losses. In-cylinder air flow is investigated for it's effect on mixture formation and flame propagation. Valve timing and VVT mechanisms are studies in relationship to engine performance. Finally special consideration is given to various alternative fuels.

Covered Topics Include:

- Engine geometry
- Combustion chemistry
- Engine Thermodynamics
- Air/Fuel ratio and Exhaust Emissions
- Engine Power calculation
- Spark Ignition Systems
- Fuel Delivery Systems
- Gas Exchange Process
- Bulk Flow and Flame propagation
- Abnormal combustion
- Alternative Fuels
- Electronic Engine Controls



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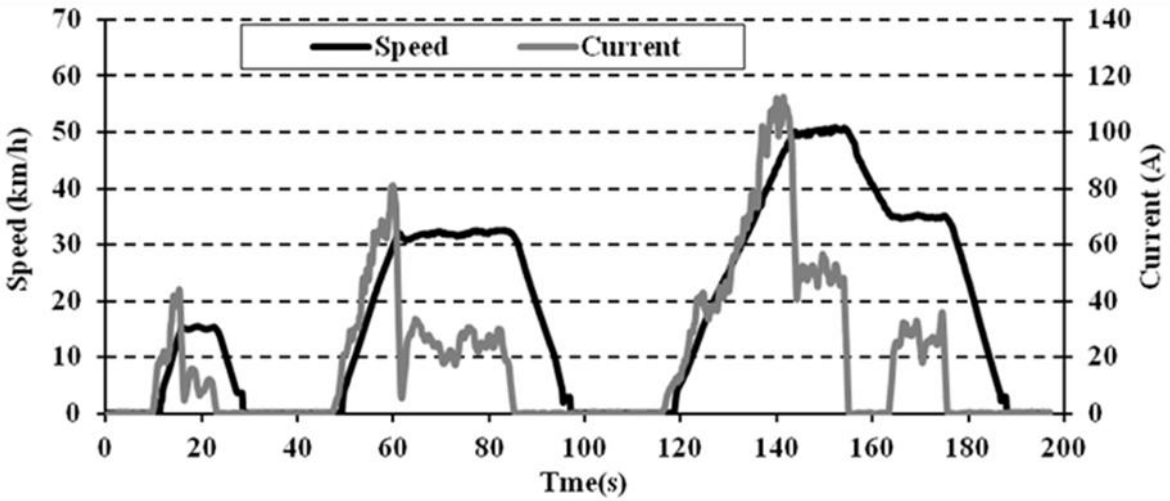
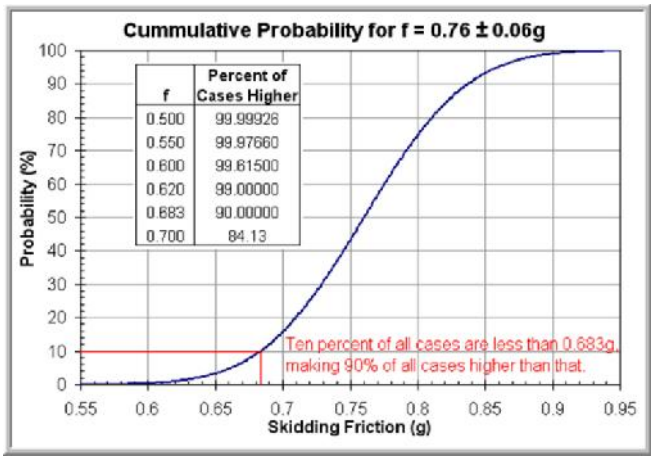
ELECTRIC VEHICLES

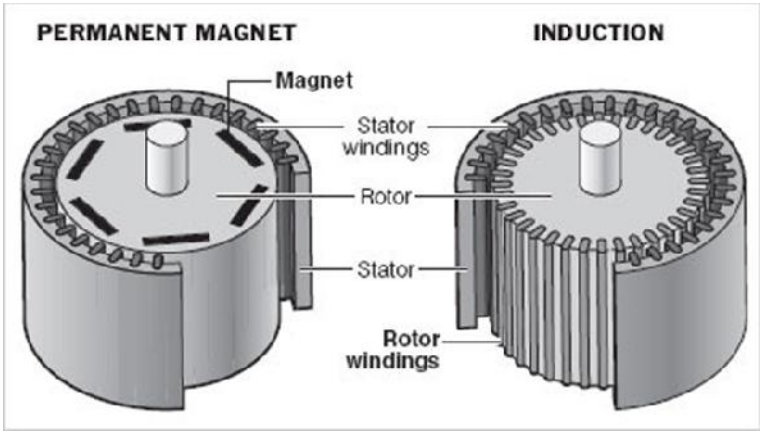


This seminar gives an overview of electric vehicles as to highlight the current " state of the art" pf EV's and their associated problems. Engine performance data from a wide variety of internal combustion engines, as well as electric motors is presented, and matched to the vehicle model to determine the ultimate energy consumption in km/liter of fuel, or km/kWh of electrical energy.



Covered Topics Include:

- Introduction to EVs
- Electric Motors, Controllers, Batteries and Charging
- Hybrid Electric Vehicles
- Advantages, Disadvantages of EVs



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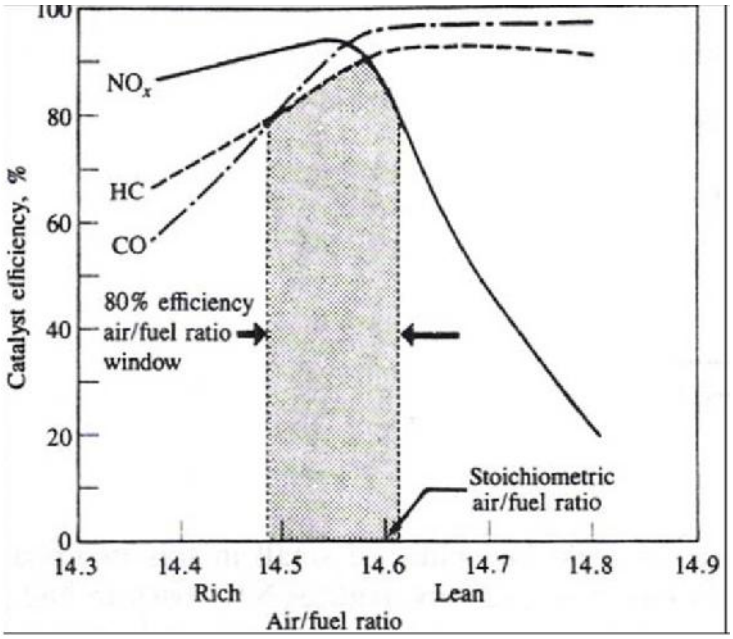
EXHAUST EMISSIONS



This seminar serves as a comprehensive overview of the formation and control of the common exhaust gas pollutants from internal combustion engines: carbon monoxide (CO), hydrocarbons (HC), nitrous oxides (NOx) and carbon dioxide (CO2). modern Electronic Fuel Injection systems. During this course we explain the effect of air/fuel ration on emissions formation and investigate the various factors contributing to combustion inefficiency such as wall wetting, crevice volume and flame quenching, piston blow-by. NOx formation is dominated by combustion temperature, and is discussed in relation to engine load, spark timing, air/fuel ratio and dilution. Exhaust catalysts and emissions control strategies are given special emphasis. Finally vehicular emissions standards and testing procedures are discussed in detail.

Covered Topics Include:

- Combustion Chemistry
- Fuel Atomization and mixing
- Wall wetting
- Crevice volumes
- Piston blow-by
- Temperature and NOx formation
- Combustion Efficiency
- Exhaust Gas Circulation
- Oxidation & Reduction Catalysts
- Cold Start Strategies
- Emissions Standards & Testing

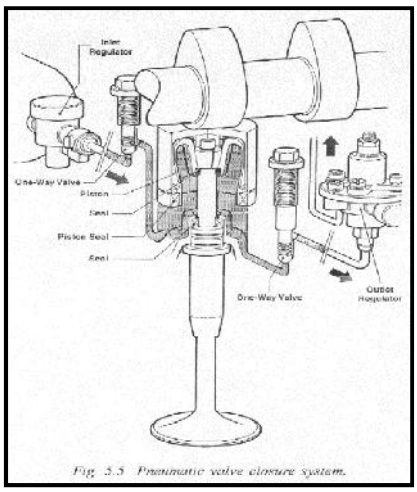


Fig. 5.5 Pneumatic valve closure system.

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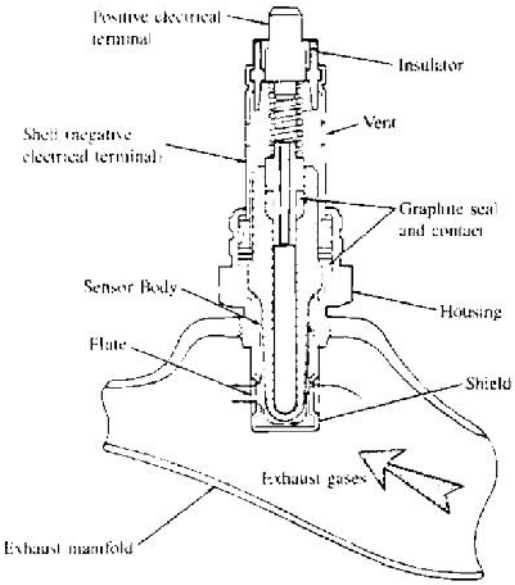
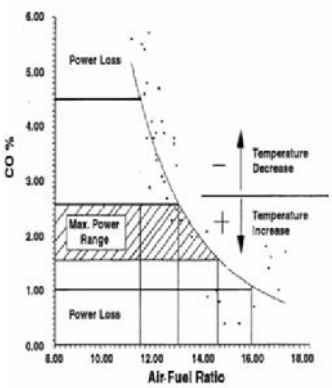
AIR/FUEL MEASUREMENT & ANALYSIS



This seminar serves as a comprehensive overview of Oxygen sensors as used to measure the Air/Fuel ratio in modern engines. During this course we explain the basic AFR control techniques used in both carbureted and fuel injected SI engines. Overall vehicle target AFR is also explained with respect to vehicle performance, emissions and engine longevity. The various O2 sensors (narrow band and wide band) are then covered in depth. Sample measurements are analyzed to give incite into the engine's operation. O2 sensor control strategies in fuel injected engines are explained in detail. Finally we will conclude with a number of important limitations and considerations when using O2 sensors for AFR measurement.

Specific Topics Include:

- Carburetors
- Electronic Fuel Injection
- Target AFR numbers for SI Engines
- Narrow Band O2 Sensors
- Wide Band O2 Sensors
- Review of Typical Measurements
- AFR Control Strategies
- Limitations and of O2 measurements



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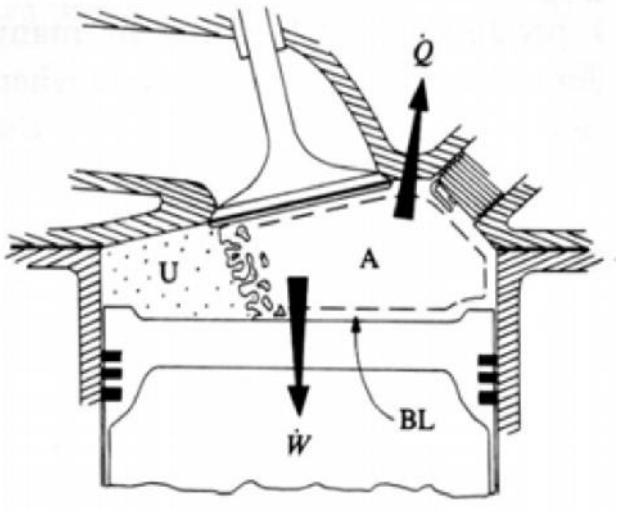
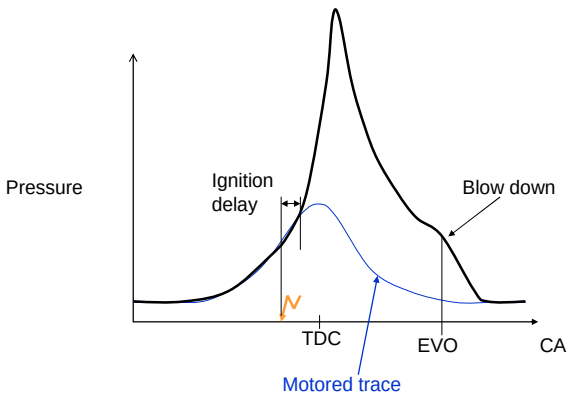
COMBUSTION ANALYSIS



This seminar serves as a comprehensive overview of combustion analysis of 4-stroke engines. Thermodynamics of the Internal combustion Engine (ICE) are covered as related to the thermodynamic combustion cycle of both spark ignited and compression ignited engines. Combustion heat release is discussed including special attention to spark and flame kernel formation and cycle-to-cycle variation, ignition delay, required ignition energy, flame propagation, “Fast burn” heat release, and flame quenching. The resulting combustion chamber pressure is modeled as a result of thermal processes plus heat addition from combustion. Actual pressure traces are analyzed for heat release rate and mass fraction burned curves. Engine acceleration compensation in data analysis is covered in detail. Finally mention is made to the effect of combustion rate on engine efficiency and knock.

Covered Topics Include:

- Engine Thermodynamics
- Heat Release Rate
- Spark Energy Considerations
- Combustion efficiency
- Ignition Delay
- Mass Fraction Burned
- Turbulence and Flame Speed
- Engine Efficiency
- Flame Quenching



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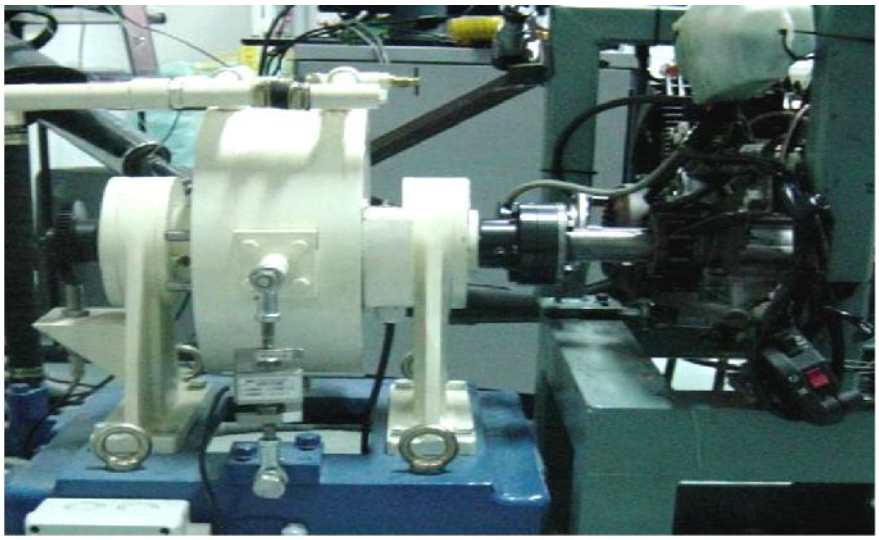
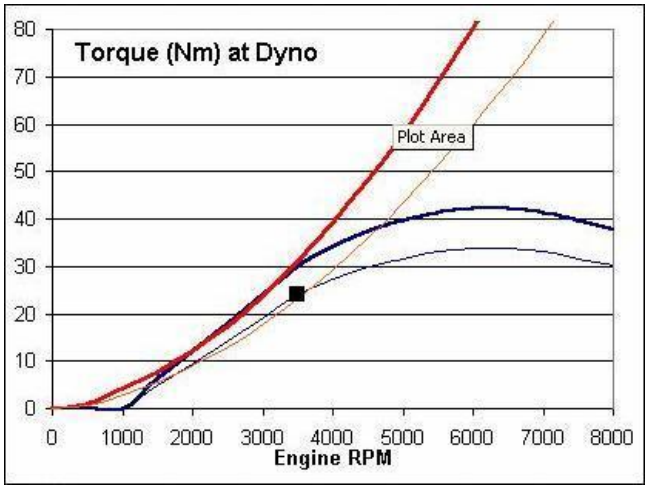
DYNAMOMETRY & ENGINE TESTING



This seminar will cover Dynamometry and Engine testing technologies. Emphasis is on the various kinds of dynamometers, how measurements are made, and how this is related with actual vehicle usage.

Part 1. Dynamometry Basics
What is a Dynamometer?
Why do we need to Dyno test engines?
Dynamometer Designs

Part 2. Measurements
Measurements: Cycle Averaged vs. Crank Angle Resolved
Instrumentation Issues
Testing: Steady State vs. Transient
Controllers
Dyno Dynamics
Maintenance



Part 3. Drive Cycles Analysis
Drive Cycles
Determination of test points
Testing and Weighing of data

Part 4 . Dynamometry Case Studies
USA
Philippians
Malaysia

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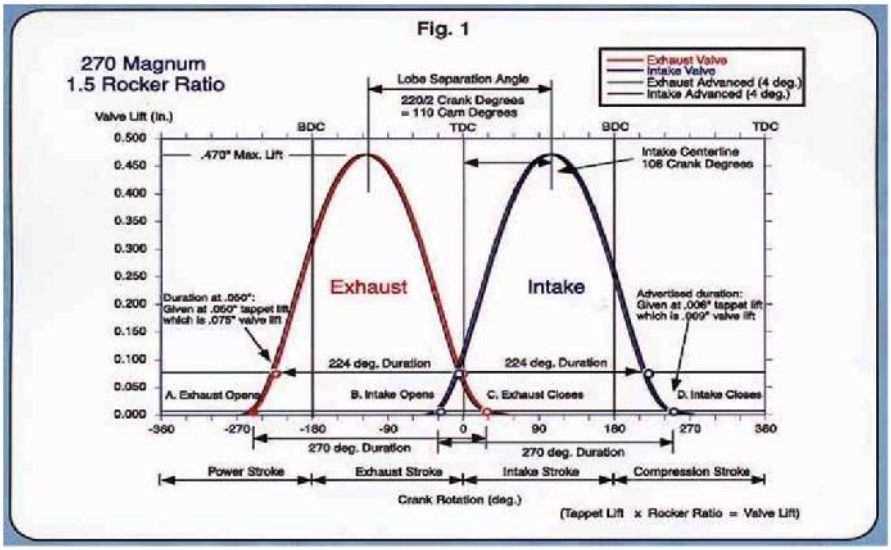
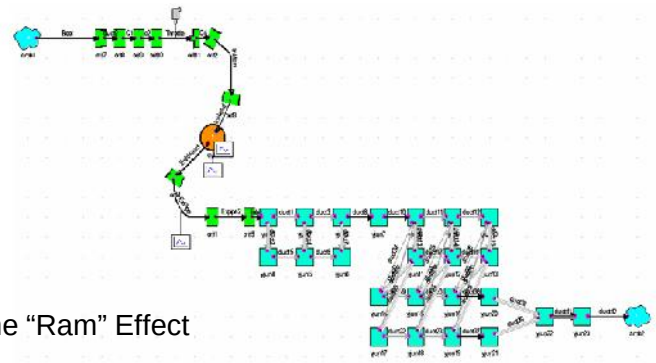
INTAKE & EXHAUST TUNING



"Tuning" is accomplished by timing the reflected waves from expansions or contractions in the intake and exhaust systems such that the reflected waves arrive at the combustion chamber at the appropriate time to increase combustion chamber density (volumetric efficiency) or reduce EGR. Naturally Aspirated F1 engines can achieve Volumetric Efficiencies of 1.3 via good tuning. This seminar shows how the intake and exhaust runner lengths are adjusted along with opening and closing valves timings to maximize air flow, and engine performance, including both parametric modeling, 1-D fluid dynamic modeling, as well as actual measurements of intake and exhaust pressure waves and engine power.

Covered Topics Include:

- Tuning Basics
- Valve Timings
- Overlap and Backwash
- 4-Stroke Exhaust Tuning
- Intake Tuning: Dynamic Effects
- Example of Tuned system vs. AM120
- Measurements:
- WOT Torque Curve
- Intake and Exhaust Pressure Traces
- Intake Tuning – Runner Length and the "Ram" Effect



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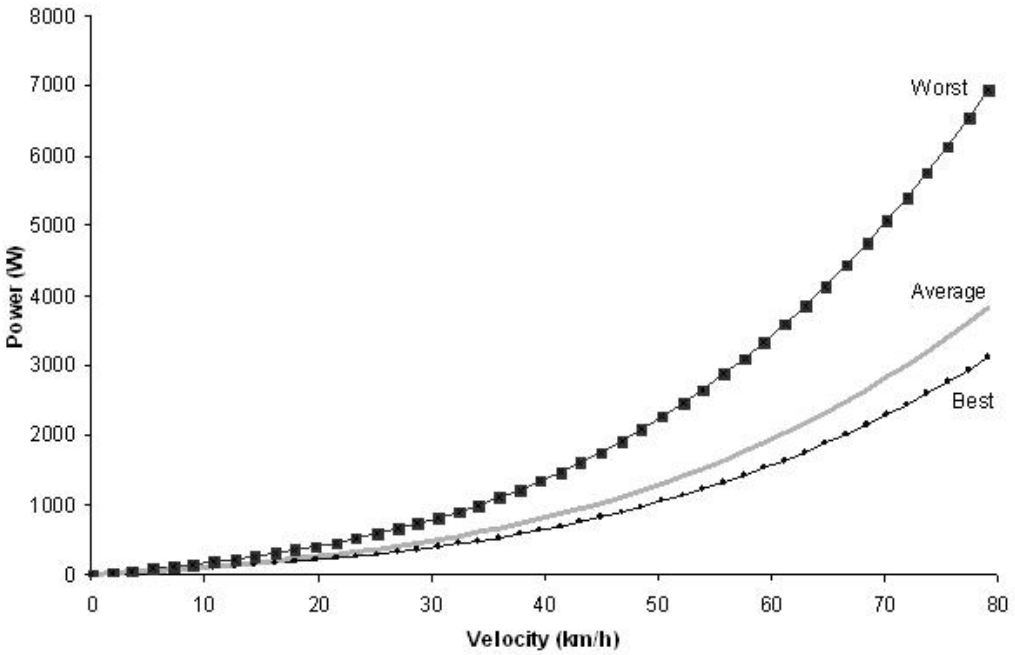
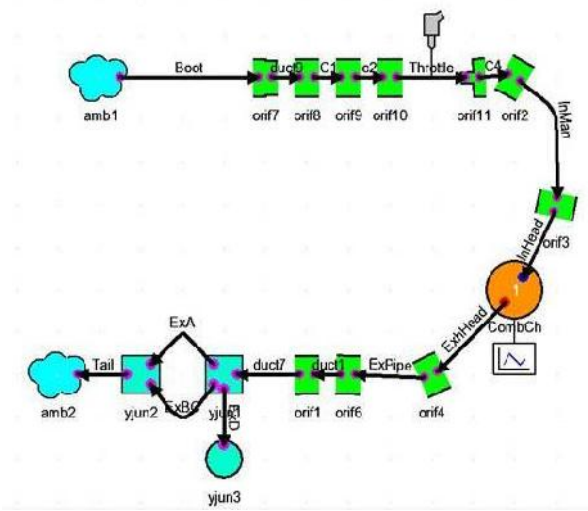
ENGINE MODELING WITH RICARDO'S WAVE



"Wave" is an engine simulation software from Ricardo Engineering. It is a 1-dimentional fluid dynamics model in which all gaseous passages are modeled as pipes of various lengths. The model includes a combustion model, a combustion chamber mixing model (for ERG), as well as various thermal conductivity and friction models and emissions models. It does not do a detailed 3-dimentional analysis of gaseous flow, or combustion, but instead uses "lumped parameter" models (such as a 2-zone combustion model). This makes it exceptionally easy to set up, and quick to run. Running various scenarios on a given engine typically takes only a few seconds, where as a 3-D model might take hours or days.

Covered Topics Include:

- Critical Engine Parameters
- Engine Model Physical Input Data
- Operational input parameters
- Cycle averaged model output
- Instantaneous model output
- Engine Optimization Techniques
- Model to experimental correlation



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ENGINE PERFORMANCE TUNING

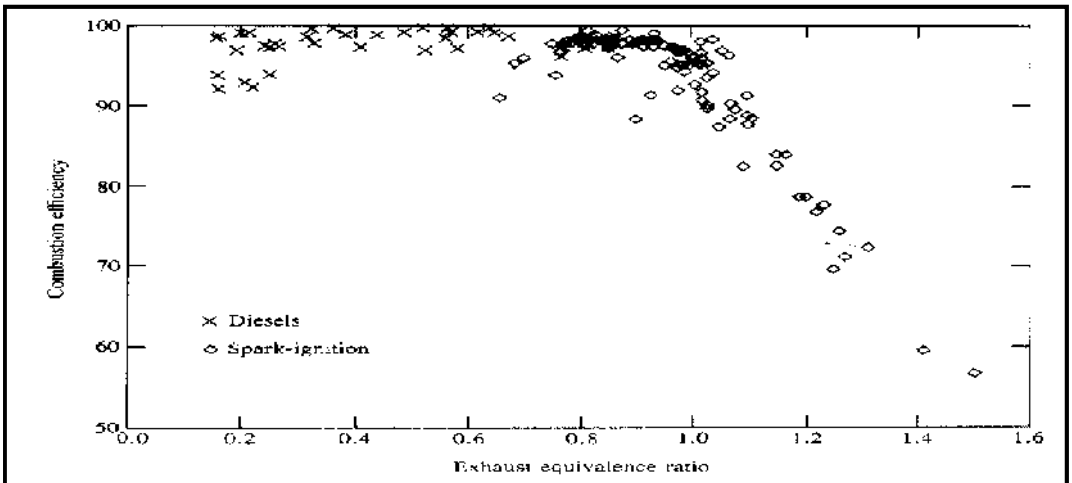

FIGURE 3-9
Variation of engine combustion efficiency with fuel/air equivalence ratio.

This seminar serves as a comprehensive overview of Motorcycle Engine Performance Tuning. It begins with carbureted AFR tuning, and AFR measurements via wide-band O2 sensors. Compression ratio measurement and calculation is enumerated.

The difference between “fast” and “slow” combustion chambers is covered. Overall power equation is explained with ramifications of each parameter independently. Intake and Exhaust Tuning fundamentals are explained Followed by ignition timing and knock. Finally Valve timing and Bulk Motion are explained in terms of their effect on engine power.

Covered Topics Include:

- AFR control of Carbureted Systems
- Basic Engine Geometry
- Power Equation
- Volumetric Efficiency
- Intake – Exhaust Tuning
- Spark Timing Optimization
- Valve Flows
- Bulk charge motion

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